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Emergence of Iron in India : Archaeological Perspective

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ABSTRACT

The evidence of iron in ancient India today weighs heavily in favour of its indigenous origin. It is clearly borne out by an examination of literary, archaeological and metallurgical data on the subject. The metallurgical skill shows clear-cut phases of technological evolution as is evident in furnace designs. The technological growth appears to be inter-related with socio-economic and cultural upsurge.

Key words : Origin, Literary evidence, Archaeological evidence, Metallurgy, Furnace.

INTRODUCTION

Iron metallurgy in India had a glorious past. This should be attributed to the ingenuity and sustained effort of the craftsmen of ancient India. One comes across references of Indian swords being presented to ambassadors (Ktesias) way back in 5th century BC and to the kings and warriors like Alexandre in 4th cent. BC. The wootz steel, once famous as Damascus steel, a prized commodity in the ancient world, originated in India. The Mehrauli Iron Pillar (Delhi) has been called the 'rustless wonder' by a modern metallurgist⁽¹⁾. This massive structure has withstood the weather and exposure to elements for thousands of years. Throughout the medieval ages the tradition continued well into the British period. It was a household industry in Mysore during Tipu's rule whose sword has generated immense interest among experts on iron. During 1857 the British found it difficult to destroy the Indian swords confiscated from defeated Indian armies. The sheer-

blades kept on breaking instead of damaging the sword-blades. The tradition of wrought iron production has survived even today among the ethnic groups who had been involved with iron working for generations. Though almost a dying art today, one may still come across some trace of iron working, perhaps breathing its last in some remote areas. Thus there is a continuing tradition of iron making in India that stretches from 2nd mill BC to almost the present day that is a legacy of the grand past. It may be worthwhile investigating the beginning and development of metallurgy of iron in India, the context and the circumstances of its earliest appearance and the precise age of its earliest emergence in the subcontinent. Before we take up these issues for discussion, a quick look at the history of emergence of iron in human civilization may be in order.

Man's first introduction to iron must have been through meteorites. These stones from the heaven, as they are some times called, could be chiselled out to shape desirable objects. With emergence of metallurgy, he learnt to heat and extract metals from the 'stone'. It was during the alloying and fluxing of sulphide ores that iron could be recognized as a separate metal. Later this came to be exploited for its own sake. Iron is one of the most prolific minerals available on earth's crust. Its strength lay in its large scale utilization for a variety of purpose. Therefore, iron as a metal undertook a long journey, from the most expensive metal (four times costlier than gold) to the cheapest one; from the costume apparel of the nobility to tool of the craftsman and the farmer. One can see the role of metallurgical skill in this progression. The innovations in metallurgy eventually led to its adaptation on a much large scale than ever before.

In India iron makes its earliest appearance in the chalcolithic milieu. Earlier, the date given by ¹⁴C determination used to range around 1000/1100 BC. More recently however, early dates have come forth from some sites in the hilly tracts surrounding the Ganga plains. Raja Nal Ka Tila on river Karamanasa dates back to 14-1600 BC – the earliest consistent dates of iron bearing levels, so far. This evidence is corroborated further by a similar evidence from Malhar, a site nearby. In view of such C¹⁴ dates, there appears to be a need to review the earlier evidence of advent of iron in India.

Two questions arise out of such data: (i) Did iron metallurgy develop indigenously in India? and (ii) Whether iron had been smelted and used earlier in India than hitherto believed. We propose to take a closer look at these issues in the following pages. Let us first focus attention on the origin of iron in India.

ORIGIN OF IRON IN INDIA

In recent years independent origin of iron has generally been accepted with more and more archaeological data coming up to reinforce this hypothesis. However, scepticism has not died altogether. There are scholars holding the viewpoint of diffusion of iron from the west. It is, therefore desirable to deliberate at length on the issue of emergence of iron in India.

Any discussion on origin of iron in India should focus on the following three points as sources viz., – (1) Literary; (2) archaeological, and (3) metallurgical.

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The line of approach that is adopted to discuss these points is:

1. Literary Evidence —————→ Indo-European philology
Early Vedic text
2. Archaeological Evidence —————→ Chrono-typological comparison
of iron tools at the earliest levels
(inside and outside India)
Early contexts of iron in India.
3. Metallurgical Evidence —————→ Iron metallurgy - a byproduct of copper
or lead working.

LITERARY EVIDENCE

The Indo-European Philology

Language, indeed is a vehicle of ideas and cultural traits. Philology has long been identified as an important medium of identification of people. That is how the Aryans — basically a linguistic group have been identified with a race and subsequently with certain cultural traits. There is a philological parity in Indo-European-Indo-Iranian and the Vedic languages. This is not the right place to go into a detailed discussion on the subject, yet its brief reference is relevant here as it cannot be avoided altogether. Scholars have debated various concerned issue from time to time. Recently^[2] the view expressed on this subject provide newer perspectives to look at various related issues. Similarly, Sharma^[3] has tried to examine the material remains to trace the movement of the 'Aryans' and the route followed by them from Central Asia towards India.

The earliest clear-cut evidence of comparative philology of Indo-Europeans is provided by the Boghaz Keui inscription of 1365/80 BC in Asia Minor (Northern Mesopotamia). We come across the names of the gods — Varuna, Mitra, Indra and Nasatya (Asvin) in a treatise of Mitanni- Hittite agreement. The terms related to horse training have been taught by the Mitanni Kikkuli to the Hittites using the (Sanskrit) numerals 'aika', 'panza', 'tera', 'satta', etc. There are also similarities between the names of the Mitanni Kings and the Indo Aryans. The Mitannis are said to be Hurrian-speaking people. 'We therefore surmise that the Mitanni once lived close to an early Indo-Aryan group, that had perhaps taken a dominant position over the pre-Mitanni population, and then become quickly accumulated as Hurrian speakers'^[4]. Parpola^[5] argues that Mitanni Aryans are related to Indo-Aryans not Indo-Iranians. Indo-Iranian relations are too well known through Avesta-Rgveda similarities to warrant any discussion on the subject here. Witzel^[4] also points to presence of certain archaic linguistic features of Indo-Iranians that may be traced in the high Himalayan regions.

It has been argued that there are traces of memories of Indo-European days in Rgveda, "Indeed, the Rgveda refers to a certain amount of symbiosis from early

on, evidenced by the non-Indo Aryan names of Brbu and Balbutha (who is explicitly called a Dasa). A process of Aryanisation must have taken place in Turkmenia-Bactria area, involving their language as well as culture" (Witzel, op. cit.). In Central Asia, Iran and other adjacent areas we have seen a new ceramic tradition by way of grey pottery that is usually interpreted as intrusive. It is interpreted in terms of immigration of new people. Parpola^[5] (op. cit.) treats the dispersal of grey ware as spread of Mitanni Aryans towards Iran-in Azarbaijan and Lake Urmia. There is also said to be a 'linkages in metallurgy'.

Movement of certain migrants - whether of culture or people - have been identified through parts of Central Asia, western Iran, Afghanistan etc. by the presence of a grey ware, cemeteries, their grave goods and also iron therein, albeit in limited number. In Marlik cemeteries such a cultural group is identified by grave goods like weapons, model chariots etc., along with specific pottery form. Horse burials along with prestige objects are also part of these funerary traditions. In some rich tombs one finds mortars, pestles and open spouted pots. In view of Caland, (1896, 51 quoted by Parpola), presence of such items are significant because of their association with Vedic funerary beliefs**. Presence of these graves in this intervening region becomes specially significant because of a reference of these customs in the Rgveda. It corroborates the textural evidence by the material remains. Additionally, it also suggests people having similar beliefs, such as those of the Rgveda living on Iranian sites like Hasanlu and Marlik and on more westerly regions between 1500-1000 BC. It may also be taken as a testimony of association of the Rgvedic people (Indo-Aryans) with the Indo-Europeans and Indo-Iranians. That the Indo-Aryans moved eastwards may be indicated in such material remains.

Talking of iron, specifically, Ghirshman^[6] observed two perceptible phenomena in the Iranian plateau - 'the invasion of Indo-Europeans and the increased use of iron'. In Eastern Iran iron first appears in the necropolis of Sialk V, cemetery A along with grey ceramic. However, iron is restricted to a couple of objects as a part of costume of some nobility as a funerary good. It assumes a utilitarian role only in the succeeding phase at cemetery B. (in ca. 1000 BC).

With this we come to the specific question of introduction of iron in India. Can we relate the advent of iron in India with Indo-European and Indo-Iranian affiliations due to the above mentioned philological similarities?

The Diffusion of Iron Technology

The philological evidence has led to a diffusionistic view point of advent of iron in India. The aforesaid movement of people and culture traced in similarity in Avesta and Rgveda, Boghaz Keui inscription of 1365/1380 BC between the Mitannis and the Hittites etc. have been taken to be significant clues of contacts

**Caland W 1896 (in German) is quoted by Parpola (op. cit, 360). It is stated that *ulukhala* (mortar) *musala* (pestle) as well as *s'akata* (model cart, (Chariot ?), are to be placed at the lags of the deceased Indo-Aryan man who had established sacred fires'. Thus it is important evidence suggesting an inter-relationship between the Vedic and the Indo-Iranian people.

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of Indo-Aryans and Indo-Europeans. That the Hittites and the Mitannis were amongst the earliest users of iron is also attested to by both literary and archaeological records.

The correspondence between the king Tushratta of Mitannis and the Egyptian pharaoh is referred to frequently in this regard. It is said to belong to pre 1200-1300 BC period wherein there is reference to a dagger with iron blade gold and lapis-lazuli handle (using 14 shekels of gold as a gift to the pharaoh (quoted by Maddin)^[7]). There is another reference belonging to early 13th cent. BC. It narrates another letter of a Hittite king Hattusili III written to Adad-Nirari I, the king of Assyria. It says, "as for the good iron about which you wrote to me, there is no good iron in my store house in Kizzuwatna. The iron (ore?) is (of) too low (a grade) for smelting. I have given orders and they are (now) smelting good iron (Ores?). But up till now they have not finished, I shall send (it) to you. Meanwhile I am sending to you a blade of iron for a dagger". (Maddin^[7] op. cit., 16-17).

There is little doubt that iron was (a) a precious commodity, (b) it was scarce and its use was restricted to decorative and prestigious items of the privileged few. Its technology was said to be a closely guarded secret. Thus till about 1200-1100 BC iron was extremely rare in these parts of Asia. It stands to reason, thus that the knowledge of iron metallurgy was hardly in a position to disperse to other regions from this source. The technology was not sufficiently developed in pre-1100-1000 BC to be transmitted to distant lands through migrant folks.

More importantly, as we have seen while discussing the position of iron in the neighbourhood of India, especially in Eastern Iran, Swat-Ghandhara, Afghanistan etc. that use of iron is confined to cemeteries that too only in the burials of the selected few (Young's^[8]). Iron I in Iran has just a few iron and bi-metallic objects in pre-1000 BC in an otherwise Bronze Age Setting. Perhaps iron comes through trade or itinerant metal smiths. Interestingly, there is a gap between iron I and II. Swords, daggers, shields, javelins, arrowheads and ornaments alongwith horse-bits and other ornaments appear in c. 1000 BC in Iran. Thus, despite the Avestic-Rgvedic philological parity, the gap between iron I and II in Iran and almost a simultaneous beginning of regular use of iron in both the places, it is difficult to argue in favour of diffusion of technology. Whether the technology reached the Indian sub-continent with the Aryans is verifiable by a close observation of the internal evidence of the Rgveda. Whether the Rgvedic Ayas stands for iron or it is a generic word for metal is crucial to the present discussion.

Iron in Rgveda

The singers of the Rgvedic hymns call themselves Arya - the noble ones, the superior people. They had kinship bond with the composers of Avesta. Talking of Rgveda to borrow Witzel's^[4] (op. cit. p. 96) words, "The earliest attested stage of Vedic and the most archaic words that occur in the Rgveda often have cognates or direct correspondance in old Iranian, especially Avestan, texts while they no longer appear in post-Rgvedic texts". (Witzel^[4], 1995, op.cit. p. 96). He has further argued that with the march of these people they absorbed some of the

local language traditions and also imbibed within their fold the local populace. "Yet, in South Asia we are dealing precisely with the absorption of not new language but also of an entire complex of material and spiritual culture, ranging from chariotry and horsemanship to Indo-Iranian poetry whose complicated conventions are still actively used in the *R̥gveda*. The old Indo-Iranian religion, centered on the opposition of *Devas* and *Asuras*, was also adopted, along with Indo-European systems of ancestor worship. In dealing with this problem we must be careful to separate the adoption of language, technology and culture which may have been responses to different albeit related processes" Whitel, *ibid.*, 112).

The studies conducted so far do not separate these three culture dimensions referred to by Witzel. On the contrary 'language, technology and culture' have been taken to be an outcome of interaction with an incoming group of people or ideas. The philological similarity of Indo-European, Indo-Iranian and Indo-Aryan forms the basis of theory of immigration of people and thereby of cultural trails. In the present context this has given rise to diffusion of iron technology with the Aryans. The Hittite-Mitanni monopoly of iron in pre-1300-1200 BC; the presence of this group in 1400 BC in Asia Minor, the common gods and language of these people and the *R̥gveda* folk are enough to suggest contacts.

This is also supposedly sufficient ground to work out a theory of transfer of technological know-how through these contacts. In view of this, the evidence of knowledge of iron to the *R̥gvedic* folk has a direct bearing on the issue of introduction of iron in India. Aryans and iron have been generally associated with each other in India, it is, therefore crucial to critically evaluate the knowledge of iron technology to the *R̥gvedic* people. Number of scholars have debated the issue of iron in *R̥gveda*^[11-20].

Three metals have been mentioned in *R̥gveda*, viz. '*Hiranya*' (gold), '*Rajata*' (silver) and '*Ayas*' (?). There is little difficulty in identification of the first two metals. Problem, however arises with connotations of '*Ayas*'^[9]. Right from the beginning of 20th century a debate ensued regarding the interpretation of '*Ayās*'.

M.N. Banerjee^[10,11,12] admits at the very outset, "But the *R̥gveda* is not a treatise on metallurgy nor does it speak of the metals in a general scientific way. Our data must be gleaned from a mass of poetic and literary metaphors, seldom in plain matter-of-fact forms of expression". The subject has been discussed at length by the present author elsewhere, suffice is to reiterate that *R̥gvedic* references on iron may be classified under the following categories:

1. Objects with sharp or strong edges (a) implements; (b) weapons.
2. Objects of daily use like pots, containers, cups etc., and tyres of chariots.
3. Metallurgical processes, viz., liquification of metal, use of bellows; arrow making etc.
4. Metaphors or similes comparing various things possessing strength, like nails, teeth, armour, walled enclosures or even persons (like Indra himself)

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of *ayas*. One thing is definite that *ayas* stood for something sharp, strong and powerful.

Early bronze possessed more strength than wrought iron. A close look at these context suggests that most of them appear to be more suitable for copper than iron. The reference Rg 1.163.9 is only indicative of colour. It may be interpreted both ways – red or black. Similarly, hands or sharp nail of *ayas* could be strong like copper-bronze or iron-both. We have come across axes or razor-blades of copper-bronze in early cultures right from early Harappan through the Harappans and Chalcolithic cultures. On the other hand swords or daggers of iron appear much later, though axes do occur in earlier contexts. It is wrong to assume that iron, especially the wrought iron of the earliest phases was stronger and better for weapons or other sharp edged tools. A good bronze which has undergone through the process of annealing has the strength of 120,000 psi while a wrought iron (with no carbon content) has only 40,000 psi. We know that the early iron found in India was wrought iron having no carbon in it. Thus, technologically also the strong, sharp weapons of Rgvedic people were more likely to be of copper - bronze than of iron especially, while presented as analogies. This assumption gets further corroborated by Rg. VI. 3. 4, which refers to liquification of metal. We know that it was copper or bronze which was molten. It reached a molten state at the time of smelting as well as casting of objects. Iron, on the other hand was produced in semi-solid state in the form of a bloom which had to be homogenized into a metallic ingot by repeated hammering and heating. Interestingly, all the above references except for two are from the late sections of Rgveda. Thus technologically speaking, the passages making a mention of *ayas* are more likely to be suggesting copper-bronze than iron. If iron was not known to the Rgvedic Aryans, it will be hard to argue that the knowledge of iron entered India with the Aryans at this stage. As pointed above (cf. Waldbaum^[13], Tylecote^[14]) at the initial stages both the metals were being smelted or worked by the same group of artisans in other parts of the Asian countries. Similar must have been the case with early Indian society. The bronze-smiths, it is likely must have discovered iron as a separate metal as a by-product of copper smelting.

Interpretation of *ayas* is difficult indeed as till much later *ayas* is a loosely used term. Milindpanho^[15], the famous Pali text of early centuries of Christian era gives a long list of professions of its time. The list includes among other professions Lohkara (iron worker) Vattakara (copper worker) *ayakāra* (bronze worker?). It is a definite proof that *ayas* was different from *loha* that was decidedly iron as it is used till today. I will like to remind once again of the terms - *Kṛśṇāyasa* and *lohitayasa* of the later Vedic age. *ayas* was used as a term in the sense of metal. Thus Rgvedic *ayas* could not be interpreted as iron.

ARCHAEOLOGICAL EVIDENCE OF BEGINNING OF USE OF IRON IN THE INDIAN SUBCONTINENT

For the study of the Indian subcontinent, seeing its size and ecological divergence no uniform rule applies. Therefore it is in order to examine the early context of occurrence of iron in separate geographical zones that may be discussed as under:

Zone A

In this zone consisting of North-West Frontier provinces and Baluchistan^[16], now in Pakistan. In the adjoining parts of Kashmir^[17] (India) a large number of cairn burials have been located. In Baluchistan^[18] at Ziwanri, Take Dap, Moghal, Ghundai Gatti, Zangian etc. hundreds of cairns were plotted and some of them were briefly excavated by Stein^[19,20] and Mockler^[21]. The burials do not conform to any uniform pattern, either in grave goods or in burial practices. They contain a variety of pottery belonging to diverse types. Even chronologically they do not belong to any specific date bracket as frequently argued by scholars (Gordon^[22], Lamberg-Karlovsky^[23]). Iron objects like arrowheads, spearheads have been found along with ornamental objects of copper, bronze and silver with pottery and bones. They are quite exclusive in form. In Swat Valley where burials and settlement sites both have been located, iron has shown up in these contexts:

Zone B

Away from the hilly tracts of the above zone, we come across the iron bearing culture of Doab i.e., Painted Grey Ware culture (PGW, hereafter) (Tripathi^[24b]). The PGW culture is concentrated in the valleys of the rivers Saraswati, Drisadvati, Ganga and Yamuna. Unlike zone A, no burials are reported from this cultural zone. Iron comes from regular habitation area. The culture appears to have a simple agrarian village economy with mud or mud brick houses. Though the evidence of Jakhera, Dist, Etah, U.P (Sahi^[24a]) hints at more urbanized traits, it may safely be said that this culture brought Doab to the threshold of urbanization. An overall advancement compared to the preceding period is perceptible at this stage. In India, glass was used for the first time in the PGW culture, with iron that appears at many places, especially in Doab from the very beginning of this culture. This is broadly datable to the beginning of the first millennium BC though a higher antiquity has been claimed for PGW (Gaur^[25], Lal^[26]) but 1000-1100 BC appears quite logical, especially on the basis of C¹⁴ dates. Only a solitary date of 1025±110 BC from Atranjikhra goes into 2nd mill. BC. But place like Bhagawanpura, which show an overlap with Late Harappan culture, may be of greater antiquity. It may be noted that Bhagawanpura and other sites showing an overlap with Late Harappan culture do not yield iron.

A macro level study of the PGW taken up by the author (Tripathi^[24b]) shows evolutionary stages within the culture. There appear to be a movement from west to east from Sarasvati-Drisadvati valley to Ganga-Yamuna Doab. One may observe the movement in time and space. This coincides with the later Vedic time. There appears to be migrations in a quest for more perennial source of water and better pastures in view of the drying up of the mighty river Sarasvati of Early Vedic times.

The sites like Bhagawanpura that are in Sarasvati plain, as already stated, do not yield evidence of iron. The technology was gradually being developed (as at Noh and Jodhpura in Rajasthan). By the time PGW reaches Doab, it attains maturity as revealed in a more standardised ceramic tradition, better settlements,

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and other skills that are evidenced at Atranjikhhera and Jakhera. Iron technology, has been learnt. Thus we have to look into the intervening region for the stages of growth of metallurgy, at least for this zone.

Zone C

Over a distance of nearly 100 Km with Kausambi near (Allahabad) in the west and Rajghat (Varanasi) in the east, we do not come across a contemporary culture worth the name. At Ayodhya, Sarasvati etc. We have come across ancient habitations but they do not date beyond 800-700 BC. In Rajghat we come across a Black-and-Red Ware culture at its earliest phase which yields iron right from the beginning. This pottery culture continues with its regional variations upto West Bengal. The intermediary areas of Eastern U.P., Bihar and Bengal are known to be using iron in roughly 1000 BC. Other important sites are Chirand, Vaisali, Sonpur, Tradih, Rajgir in Bihar and Pandurajardhibi, Mahisdal, Mangal Kot, Hatigra etc., in Bengal. This phase not only show contemporaneity with zone B but also possesses many common cultural components like beads, bangles, disc etc. The nature of settlements is also similar. However, the pottery traditions are quite distinct in zones B and C. This region has generally an underlying chalcolithic phase. Iron, in this region is introduced in the chalcolithic milieu, the cultural traits continue unabated without apparent changes even after the advent of iron for quite some time. The middle and lower Ganga plains have yielded valuable evidence on iron during the last one decade. The data is still to be fully recorded and evaluated. It may be worthwhile drawing attention to two such instances. In Bengal at sites mentioned above, we are coming across evolutionary stage of iron working. Most significant among these is Mangalkot. Though, it is difficult to agree with Dutta^[27] (1992: 293-303) about the use of meteoritic iron here (on the basis of presence of nickel alongwith cobalt and copper in iron objects), but he has convincingly shown on the basis of a phase wise distribution of iron that the technology that has been at an elementary level at first evolves with time. Samples from Mangalkot and Pandurajar Dhibi indicate extraction at a low temperature having plenty of slag inclusion in the finished objects (De and Chattopadhyay^[28]) at first. However, the samples pertaining to subsequent phases show better metallurgical skill. On the basis of C¹⁴, these phases have been assigned a date bracket of 1000-1200 BC.

In the middle Ganga plain, we have come across an equally interesting evidence of early use of iron in the Karmanasa valley in Mirzapur Dist. of U.P. Tiwari^[29,30] has excavated the sites like Raja Nal Ka Tila and Malhar that have yielded consistent dates from 1400-1300-1000 BC along with rich evidence of iron working, complete with ore, smelting and smithy. This has emerged as an early and key iron producing zone in mid Ganga plain. It becomes still more significant because of its location near an alluvial zone that is otherwise deprived of mineral deposits.

Zone D

This cultural and ecological zone consists of parts of central India, i.e., Madhya Pradesh, south-eastern Rajasthan and adjacent areas of Maharastra. It is

separated from zone C by the Vindhyan and Aravalli ranges. It is rich in ore deposit and has a plethora of chalcolithic cultures that precede the iron bearing strata. This area is known for its richness in copper-bronze objects from the chalcolithic period onwards. This has Black-and-Red ware as in the above zone but culturally speaking it is quite different. The map here shows them under the same sign but a spatial gap is evident. The key sites of this zone are Ahar, Eran, Kaytha, Nagda, Prakash, Bahal etc. Ahar (Sahi op.cit.^[24a]) is dated to pre-1300 BC and is shown to be the sites of earliest iron using culture. At Ahar, iron is reported from chalcolithic level itself which is dated to 1400/1300 BC by C¹⁴. Iron is used by Black-and-Red ware using chalcolithic culture at Prakash, Nagda and Bahal around 900-1000 BC. Here the chalcolithic pottery and other cultural material continue to be used in the succeeding iron bearing phase and hence the early date. Other iron using sites of this zone have been dated roughly to 800/700 BC as they all show a gap between the chalcolithic and iron bearing levels. Without repeating the evidence of Ahar and Eran again, suffice is to say that the chalcolithic cultures of western and central India represent an independent unit of culture wherein there is an early occurrence of iron.

Zone E

In Maharashtra in Deccan plateau there is a hiatus after the chalcolithic phase. In more remote areas we come across the megalithic burials of Vidarbha in eastern Maharashtra. It yields evidence of great significance in connection with iron. The districts of Bhandara, Nagpur and Chandrapur are the centre of Megalithic culture. Excavations conducted at Takalghat-Khapa (Deo^[31,31a]), Mahurjhari, Junapani Naikund etc., have yielded iron at the earliest levels. Both habitation sites and burials thereof have been excavated, revealing pottery of special type and objects like sword, spearhead, arrowhead, ladle, handled pan, chisel, spike, fish-hook, horse bit, bangles etc., Deo^[31,31a] dates it to 800 BC. Hundreds of iron objects have been found in these burials (Deo and Jamkhedkar^[32]). Significantly, Naikund in Nagpur has yielded an iron smelting furnace, complete with tuyere, slags and tiles used for shaping the furnace.

The evidence of iron in this zone has some affinity with the Cairn burials of North-Western part of the Indo-Pak subcontinent (Zone A). The horse burials along with horse bits and other ornaments are new feature here and may be compared to similar evidence in Zone A. However, on the basis of material culture we cannot suggest any relationship between these two zones. The cultural material however, is different. The pottery as well as the metal objects have their own specificities. But these people seem to be warriors who perhaps indulged into marauding. How large was their area of operation? Where did they come from? are some of the issues that need to be resolved? These cultures are generally located on the banks of small rivers or streams in the hilly areas that provide them both raw material in the form of minerals as well as arable land for small scale agriculture. These were predominantly hunter-pastoral groups as shown by the analysis of the bones and other cultural material revealed by various excavations (Deo and Jamkhedkar^[32], op.cit.). Pure copper objects were used by them.

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Conditioned by the ecosystem, their life-style perhaps did not allow them to grow into centres of affluence despite a relatively heavy use of iron implements. Iron was primarily used as a means of offence or defence. Upto two third of tool types belong to a category that they served this purpose. Sickles are found rarely. Ploughshare are not known to megalithic people. Thus agricultural implements form a small percentage of the total tool repertoire-eleven objects out of 1352 objects indicate the economic priorities of the society. Hoe and bill hooks used for digging are main agricultural tools. Crops include common pea, black gram, wheat, lentil and Indian Jujube (Naikund). 'The quantity of grains recovered and the small floor area of occupation... indicate that at least in Vidarbha (the people were) not settled agriculturalists but mostly pastoral community...' (Deo, op.cit., p. 90). Local iron ores were used by the smelters of Naikund 'Iron ore was located in the form of a rubble in a *nala* that lies about 1 Km southeast of the smelting site'.

Zone F

A large number of megaliths of diverse types have been brought to light from the peninsular India (Sundara^[33], Moorti^[34]). A typical Black-and-Red ware characterises them. Roughly dated between 1100-300 BC, they are rich in iron. The site of Hallur in Tungabhadra basin is dated to 1100 BC by C¹⁴ in its neolithic-megalithic overlap phase. Recent TL dates from Kumaranhalli has a date range between 1440 BC & 1130 BC.

There is an overlap between the Neolithic cattle breeding societies and subsequent iron using cultures in Peninsular India as evidenced by excavations like Hallur. The cattle herding continued to be the primary occupation even during the Megalithic period. The Megalithic society patronised chieftdom with gold objects in a couple of graves including diadems. In peninsular India, there are as many as 399 habitational sites giving us a good insight into the life of the megalithic builders (Moorti^[34], op.cit.). The emphasis in this zone also appears to be more on herding and stock raising than agriculture. Coarse grains like Kulthi, green gram, gram and cereals resembling 'ragi' are found. Rarely there is evidence of rice (Cromlechs at Graserpet in Coorg, Koppa in Karnataka and Adichannalur have yielded paddy husk). The last mentioned site also yielded millet seeds kept in a bronze container. The economy in this zone was also predominantly pastoral. At Maski out of total 32 iron objects we come across a solitary sickle blade. "Except for a bangle, a ferrule, a chisel all other iron objects are weapons of offence". Brahmagiri yielded merely two sickles. "Though a Roman plough-coulter was found here but that belongs to early centuries of Christian era...". Those mobile pastoral groups had to rely on self protection. This is suggested by the large number of tools of offence recovered in burials as well as habitation sites" (Deo^[31,32], op. cit.). A close look at the region-wise typological figure (Fig. 1.1) easily demonstrates very distinctive features in the tool repertoire, showing thereby the cultural preferences of each area in accordance with their specific requirements. But it may safely be suggested on the basis of the aforesaid that iron originated simultaneously at more than one centre, discussed above.

METALLURGICAL EVIDENCE

Incidence of Iron – Rich Copper or Iron as a by Product of Copper Working

It may be worthwhile examining various conditions, elaborated upon by archaeo-metallurgists working on this specific issue. The subject of simultaneous reduction of iron (alongwith) copper has already been examined by the present author elsewhere. That iron oxide was being used as a flux in copper smelting has been testified by several metallurgists in course of their investigations of ancient as well as traditional working. Iron was being used as a flux by the traditional copper smelters at Anjileh near Yazd. They discovered that for 6 kg of cerussite ore, 150 gm of hematite ore was used as flux. The furnace had a square section having a height of 8' ft., which was broad at the base and tapered towards the top. In course of the observations a salamander or 'bear' – a 3000 pound ball of metallic iron was discovered. It was an actual by-product of copper smelting (Wertime, 1980^[35], 1-24).

Simultaneous reduction of iron with copper will take place* under certain circumstances, like: if iron oxide was added as flux in copper smelting and the percentage of silica and other gangue material present in the charge was low, iron oxide will react in a way that it will get reduced with copper resulting into streaks of iron in copper tools.

Secondly, there may be a possibility that iron oxide gets reduced by solid carbon or carbon monoxide gas before it could react with silica etc., to form fayalite and thus it got added to the molten copper metal. This will change the colour of copper somewhat and also make it hard to cold work. Tylecote^[36] have reported many magnetic copper objects showing the presence of iron therein.

It is some such situation which must have resulted into a heavy percentage of iron in the Harappan copper objects referred to earlier. Such situation may lead to recognition of iron as a distinct metal from copper in due course of time but can not indicate the knowledge of iron metallurgy as such.

Deduction: An Indigenous Origin of Iron in India

A detailed evaluation of the literary, archaeological and metallurgical data on iron technology in ancient India is suggestive of its independent beginning in the subcontinent. Closer examination of Rgvedic references to metal and metallurgy, especially of *ayas* reveals more clearly the nature of this word. Its implication is of crucial significance to the present issue.

Occurrence of iron in different archaeological zones has been reviewed and re-evaluated. Attempt has been made to locate (a) specific typological, chronological and cultural setting of iron in each zone (defined above); (b) inter-regional interaction and relationships relevant to technology-transfer; (c) locational aptness of a region for acquisition and distribution of iron technology to other parts of the

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subcontinent and thus being instrumental in diffusing iron technology. Answer to these points are directly inter-linked with origin and dispersal of iron metallurgy in India. It is now almost universally accepted that iron technology is a by-product of lead and copper working. We may summarise the discussion to underline the emergent points.

R̥gveda being the ancient most literary text of India roughly datable to 1st half of the 2nd mill. BC has a direct bearing to the origin of iron in India. The echoing of Indo-European and Indo-Iranian association of R̥gvedic Aryans may be inter linked with the material milieu. Several common points have been underlined and need not be elaborated upon again. The departure of the R̥gvedic Aryans (from its westerly kins) may be placed at pre-iron stage. Or it took place at a stage when iron was scarce and its use restricted to only a privileged few of the society. We concentrate on the use of the word *ayas* in R̥gveda. The word occurs forty times in R̥gveda. It has been interpreted variously by scholars. The discussion here favours its usage as metal or at best as copper or bronze. I will like to pose a question here. Its implicit answer is very relevant to the present issue: why was there a need to coin the terms *Krisnayas* and *Lohitayas* in the subsequent stage? (Vijasaneyi Samhita of the Yajurveda 18.13).

"Hiranyam ayahsyamam loham Sisam trapu", the word *ayah* here qualifies both to *Syamam* (dark/black) and *loham* (reddish). It stands to reason that with appearance of a black metal (iron) there rose a need to coin a fresh term to explain the new product as distinct from the (earlier) reddish metal (*ayah loham*), that is copper. Archaeological evidence on iron technology at its earliest level has been examined^[37-41] in divergent cultural zone that existed in different ecological settings. Each of these cultural units was almost independent of each other having little common traits. The geographical barriers hindered interactions and the economic background imposed restrictions. In many of these zones the recent chronological plotting of C¹⁴ dates are going back generally to 12-1100 BC or in certain parts in the 14th-13th cent. BC or may be even earlier. These dates are earlier than those sites on the borders of India. Thus the archaeological evidence suggests-

- (a) an independent and earlier beginning of iron in India.
- (b) simultaneous beginning of iron at more than one centre in the subcontinent.

Having discussed the emergence of iron in India at length, a look at the nature

*The comments of R.F. Tylecote^[36] are significant in this connection "...How easy it would be to reduce iron out of the fluxes during reduction smelting of iron-fluxed copper oxide ores. Normally, all operations would be reducing and, unless there is very careful control, iron would be dissolved by the molten copper. Many of the early analyses do not show substantial amounts of iron, probably because this element has not been sought, or else the metal was the product of sulphide ores. Recent work has shown that a good deal of early copper is strongly magnetic and, where the cause of this has been sought, it has often been found to have been due to the presence of dendrites of a high-iron solid solution in the copper. At room temperature, this alpha-iron is strongly magnetic. Iron dissolves only slightly in copper and when its solubility is exceeded (less than 1% under average conditions of cooling), it is rejected as a magnetic iron-rich phase" (p 189).

and type of iron objects is called for. The accompany pattern (Table 1,2, & 3). Iron at Stage 1 (from earliest time to 7th-6th century BC) is used primarily in war and hunting or as nails, clamps rods etc. By way of exception we come across sickles, how and even ploughshare from a few sites. It is at the next stage (7th-6th BC to 3rd century BC) that with improvement in metallurgical skill iron is employed in other productive sectors. This explains why there is little impact of iron technology in socio-economic milieu. Before this is being examined a few words on the furnaces that were being used in early smelting may be in order here.

Furnaces in Ancient India

In India the earliest furnaces belonging to ca. 1000 BC are rarely reported. The early iron bearing levels have generally yielded vague looking ash pits/burnt earth etc., along with some slags and rarely with blacksmiths' tools (viz., a pair of tongs from Atranjikhhera^[42], Dist. Etah, Period III or Painted Grey ware level dated to ca. 1000 BC). Similarly, at Noh and Jodhpura in districts of Bharatpur and Jaipur in Rajasthan furnaces with side nozzles but of indeterminate shape have been reported^[43] from Painted Grey ware level. In most of these cases, generally a round shallow pit full of ash is the main reminiscent of the furnace; the superstructure is invariably missing. It may be worth while examining here the designs of individual furnaces as revealed by the excavations from protohistoric to historic periods.

Shallow pits have been unearthed by way of remain of furnaces at Chalcolithic sites. At some of them iron objects and slags have been found to be associated. At Pandu Rajar Dhibi^[44] dated by ¹⁴C from 1045±55 BC to 920±50BC iron objects, have been found in a small number. Associated with iron are slag and 'ash pits' identified as iron furnace. The subsequent post-chalcolithic cultural deposit (Pd. III) also yields similar remains along with a crucible. Examination of slag-visual observation, microstructural and chemical analysis led to the deduction that smelting was done at a rather low temperature 'below 1100°C'. The hearth was filled with alternate layers of charcoal and ore. There is no clear cut evidence of use of tuyeres. Some of the samples, particularly the one belonging to Pd. III (i.e., post chalcolithic) have fayalite (iron silicate) in high quantity. This also proves, according to Chattopadhyay an elementary knowledge of iron smelting – the objects thus produced with plenty of iron silicate are brittle. However, this does not give us a very clear idea of the shape of the furnace at Pandu Rajar Dhibi.

At Atranjikhhera (mentioned above) a pear shaped fire pit has been reported from the upper phase of the Painted Grey Ware Culture. To quote Gaur^[45] (1984, op.cit). "In some cases the openings for introducing nozzles of the bellows for fire could be clearly seen. ...Inside these pits were found rounded tapering clay-lumps and finished iron tools". A pair of tongs which might have been used by the blacksmiths lies outside the pit along with iron slags and also charred animal bones. Gaur (op. cit.)^[45] feels that it is "quite likely that these fire-pits were iron furnaces, though the possibility of one or two of them being community – hearths

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cannot be ruled out, since near one or two such pits a few earthen pots and charred animal bones* were also found." Whatever be the case, slags, smiths' tools as well as finished iron objects indicate iron working. Nevertheless, the shape or design of the furnace are not easy to reconstruct from the above description.

Excavations at Jodhpura (Lal^[46] 1988), Dist. Jaipur in Rajasthan has also brought forth a similar evidence from PGW cultural phase, i.e., pits associated with slags ashes etc. Here 'furnace with a side hole into which the nozzle or bellows could have been inserted were found. It produced objects like axes, daggers, spearhead, arrowhead, nails, tongs etc.

A clearer evidence in this context comes from the PGW level from Jakhera in Dist. Etah (personal observation). Although a full report of the excavation has yet to be published, the preliminary examination of the material by the author gave some idea of iron working there, is significant indeed. The lower portion of the furnace with slag, burnt charcoal etc., has been unearthed there. It appears like a circular shallow pit. Not much of the superstructure has been found, nor reconstructed so far by the excavator from the bowl shaped slag lump with cinder, charcoal etc., found in situ. However, I personally feel that it should be a remain of a slag pit furnace.

During the excavations in 1999 Tiwari** exposed a furnace belonging to Period II at Malhar in Dist. Chandauli (U.P.). It is a cylindrical clay furnace measuring 1.30 m and 0.80 m (on the inside) and 1.38 and 1.00 m (on the outside) their extant depth is about 35 cm. The inside is burnt. Slag adheres to it. Tuyeres, slag, iron axe and potsherds (dish, bowl, vases of grey ware, black slipped ware, red ware and a few coarse variety of BRW pieces) were found with it.

The sites of Munsakhand village, Lohsanwa (near the village) Babawali Pahari, Amchuan and Geruwatwa Pahar have yielded interesting evidence of iron working. This area is rich in iron ore that is named after Geru or hematite. Lying within the Agaria belt, it is said that iron smelting continued in this area till recently. Thus, ore, forests (for charcoal) and heavy smelting evidence are all found in one area here. There are several furnaces submerged under the Munsakhand and Nagwan dams which may be still seen during summers when water level goes down.

Naikund^[47], a megalithic site, 42 kms., Northeast-east of Nagpur in the Vidarbha region in Maharashtra on the left bank of river Pench has yielded valuable evidence of iron smelting. The site has yielded both burials as well as habitation deposit of 1.50 metres thickness. It has been dated on the basis of C¹⁴ dates to C 700 BC 690 \pm 110 BC \pm 400BC.

A careful excavation with the help of a resistivity meter at Naikund led to discovery of an iron smelting furnace. It was a small furnace with a 30 cm diameter and 25 cm height. The furnace was constructed with circular clay bricks (Pl. XIII A, Deo and Jamkhedkar^[47] Fig. 1). The bricks were piled one above the other, the upper surface of the lower brick was convex and the lower surface of the upper

[illegible]

[illegible]

Table 2 : Distribution of iron objects from archaeological sites Stage - II (middle Iron Age) (NBPW Level) Artifacts

[illegible]

Table 3 : Typology of Iron Objects Discovered During the Stage III

Hunting tools		Household objects	
Spearhead	☆	Knife	☆
Arrowhead	☆	Yong	●
Point	●	Disc	●
Blade	●	Ring	●
Spear lance	●	Spoon	☆
Dagger	☆	Sieve	☆
Sword	☆	Cauldron	☆
Elephant goad	☆	Bowl	☆
Lance	☆	Bishe	☆
Armour	☆	Building material & carpentry/masonry tools	
Helmet	☆	Rod	●
Horse bit	☆	Pin	●
Caltrop	☆	Nail	☆
Agricultural tools		Chisel	☆
Axe	☆	Clamp	☆
Sickle	☆	Pipe	●
Spade	●	Socket	●
Ploughshare	●	Plumb bob	●
Hoe	☆	Chain	☆
Pick	☆	Door hook	●
		Hing	☆
		Spike	☆
		Tweezer	☆
		Anvil	☆
		Hammer	☆
		Scissor	☆
		Saw	☆
		Socketed tang	☆

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☆ Definite existence

●

Confirmed data not available

brick was concave, thus they fitted into each other. The inner side of the bricks had turned black due to firing in reducing condition. The outer side of the bricks remained brownish red. A hole was provided at the bottom for tapping slag. A few of the bricks were found fused with slag and cinder. The tuyeres have a length of 16 cms and a diameter of 2.5 cms/3.6cms. Two tuyeres of variable diameters in heavily vitrified condition have actually been recovered from excavations. Both tuyeres are made with clay with a heavy mixture of quartz grains.

The trench also yielded pieces of ore which has been described by Gogte^[47] (p. 54) as 'crystalline to microcrystalline micaceous hematite quartzite which is generally with manganese ores.' The site is located in close proximity of

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manganiferous belt. The Parshivni open cast manganese mine is about 3 kms., away from Naikund. Manganese ore and the associated rocks like vein quartz, gondite, micaceous schist were found to be present in the trench. Iron ore pieces were 3-5 cm size. Thus the source of iron ore of the Naikund iron is quite evident.

Nearly 40 kg., of slag and cinder was found in the trench. A piece of the tapped slag (Pl. XIV. B, Gogte^[47], op.cit.) had fused with bricks which formed the hole for the exit of the slag, on the other side cinder and partially reduced iron ore (micaceous haematite quartzite) were fused together. A piece of 0.5 cm thick and 5 cm long corroded iron rod was also found in the proximity. Interestingly enough, well preserved iron objects in a fairly large number were found from Naikund. The commonly occurring shapes were dagger, knife blade, adze, hoe, axe, chisel, clamp, hook as well as utensils like dishes, ladles or lamps.

The efficiency of smelting has been judged and estimated by Gogte^[47]. According to this for 3 to 3.2 kg., of pure iron 10 to 12 kgs., of iron ore was used (p. 33). The chemical analysis of ore, slag and cinder has been given by him in Appendix III (p. 56-59).

Excavations being conducted at Balathal by Deccan College and Post Graduate Research Institute (Deemed to be University), Pune have yielded iron smelting furnaces belonging to Early historic period. It has a tapering design with a small opening at the top. Slags and other finds associated with the activity have been located.

At Khairadih in Dist. Ballia in Uttar Pradesh three furnaces in a row have been exposed during excavations (Tripathi^[48], Fig 2). These furnaces belong to the late NBP phase and are partially underground (Like the Baster furnaces). The underground pits have a flat base, the diameter is about 20 cms. The pits are clay lined and about 39 cm. deep. The superstructure is broken – some portion of the top is detectable in the fallen debris in situ. The furnace is quite similar in shape with the one described by Voss (op.cit.). Clay mixed with straw and sand was used for making the furnace wall. A bamboo plastered with mud was used as a tuyere at the surface level. During smelting the slag dropped at a lower level away from the shaft perhaps through channels provided for the purpose. The slag fell in the form of drippings. Nearly 30 kg of slag was collected leaving the rest in situ. It suggests a heavy working. This side of the site appears to have been occupied by the artisan class. Nearby, (trench CC'6) another furnace complex was located yielding a variety of evidence of copper, glass along with traces of iron working. Slag, ore, crucible, crushers, hammers with short handles, four legged oblong quern*, mica, silica in a solidified form are all found in a small trench. This appears to be some kind of a composite working area. The objects of iron that have been recovered from this site and analysed range from pure wrought iron to steely iron. Some of them show a uniform pattern of cementite

*Animal bone and limestone were used as flux as has been suggested by Banerjee (N.R.) in connection with smelting evidence from Ujjain excavation.

** Personal communication.

and pearlite indicating the high standard of iron being produced at Khairadih by 300-200 BC. The evidence of metal working unearthed at Khairadih helps us in reconstructing the metallurgical processes in vogue at that age.

Thus the foregoing gives us a fair idea of the type of furnaces that were being used at different stages in ancient India along with the metallurgical skill for better understanding. At the earliest level iron workers seem to have produced iron from ores by smelting processes much like the one used to produce copper. The bloomery iron produced in these furnaces had to be beaten and hammered repeatedly in open forges. Iron thus produced could easily be forged and shaped into desirable objects. At the beginning though the objects were small and restricted in number with experience and experimentation the technology appears to have been perfected. The archaeological evidence may be substantiated with the ethnological evidence as there appear to be quite a bit of similarity between the ancient furnaces and those of the traditional iron workers of India – many of them still in operation. In the next part we propose to concentrate on the ethnological evidence.

TECHNOLOGY VIS-À-VIS ECONOMIC PROSPERITY

It is a frequently debated issue among the archaeologists whether technology played a positive role in bringing about material prosperity in society. This has been more earnestly debated in connection with iron technology. Two diametrically opposite positions have been taken by scholars. It is not intended to reopen the discussion anew at this juncture. It is, however intended to evaluate the role that newly emerging technological know-how could have played in the socio-cultural set up of the 1st millennium BC. The impact of technology in cultural milieu is proportional, firstly to the degree of its social adaptation and secondly to the level of mastery achieved in technological skill, i.e., the level of efficiency attained by the artisan class involved in the production of artifacts. Talking in the present context, it may be apt to focus our attention on these points at the three stages defined above.

At stage I, that is immediately after the advent of iron technology its adaptation is minimal. We rarely come across bimetallic objects in India but in other parts of the world iron was a precious metal used along with gold or copper-bronze for the privileged class either as ornament or for some ornamental/ritualistic purpose. In India, however hunting or war weapons were used at stage I as clearly borne out by the Tables given, above. There are either bits of iron or indeterminate objects or at the most some simple hunting tools, nails etc. At a slightly later phase of this stage, the number and types of hunting tools increases. However, the use was still restricted to hunting and war weapons, mostly. This fact is evident in the itinerary of tool types during Painted Grey Ware (PGW) or Black-and-Red Ware (BRW) periods in the Upper and Mid-Ganga Plains. The newly acquired technological skill at this stage has been employed in warfare. The social priorities may well be understood even by a cursory look at the tool typology. Many of the hunting tools are replica of their stone/bone prototype.

***Personal communication.*

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REGIONWISE DISTRIBUTION OF IRON OBJECTS DURING EARLY STAGE

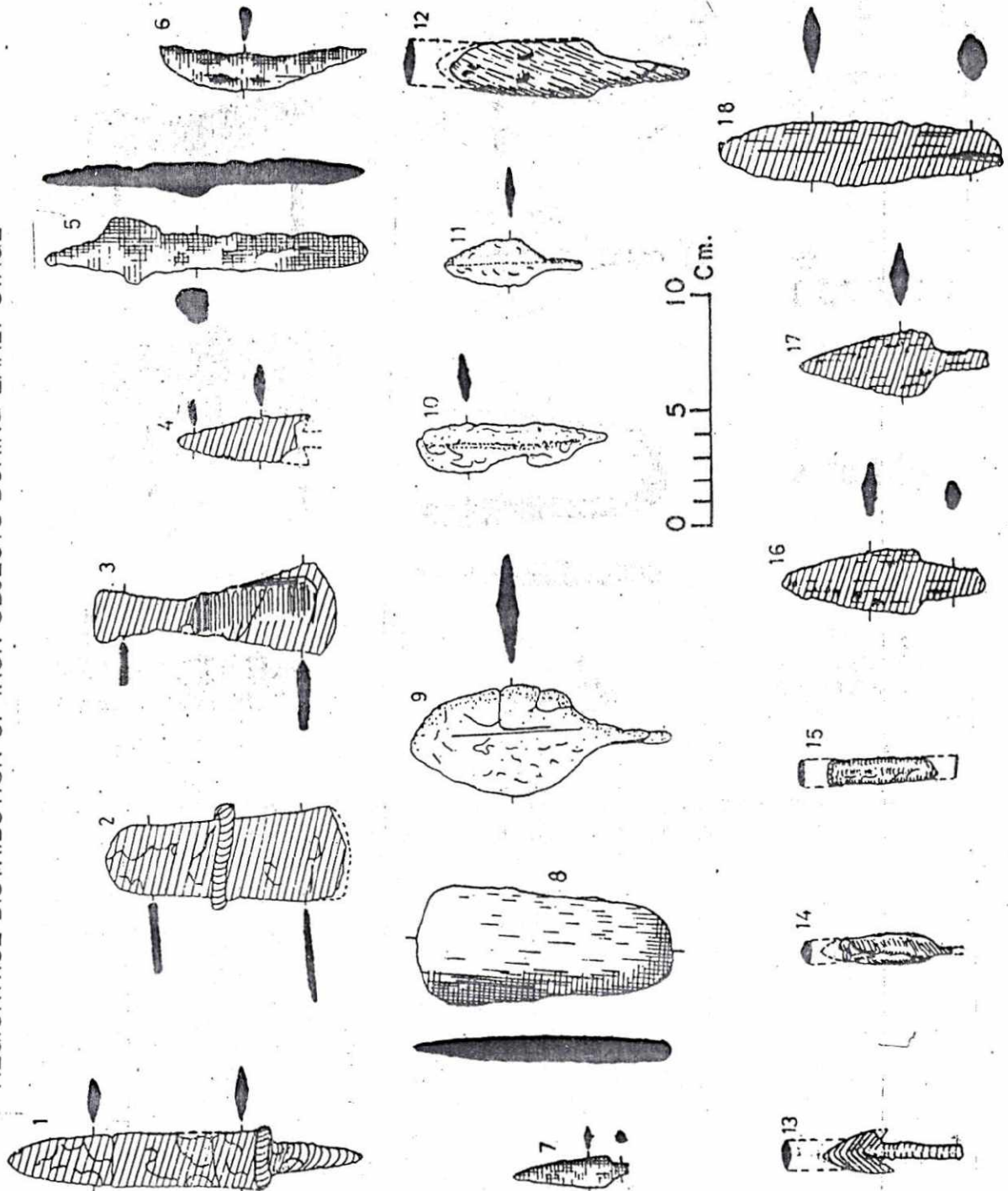


Fig. 1 : Zone - A 9-11 (Swat Valley); Zone - B 12-15 (Atranjikhhera); Zone - C 7-8; Zone - D 5-6 (Prakash); Zone - E 1-4 (Takalghat - Khapa); Zone - F 16-18 (Hallur).

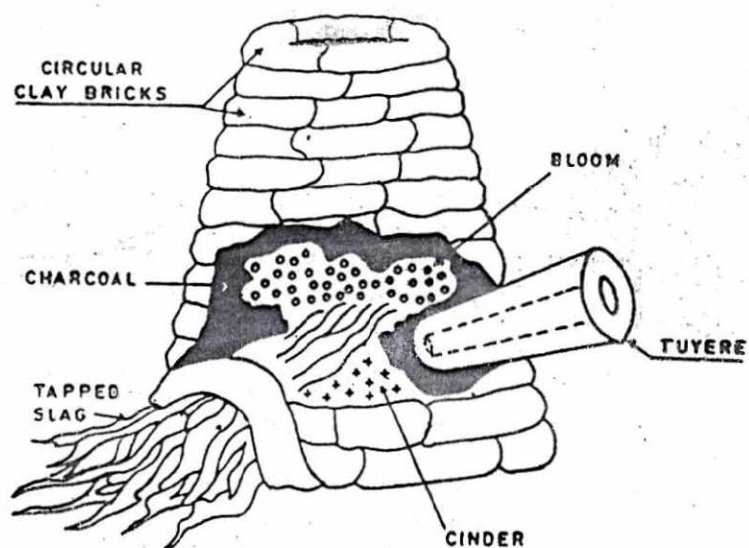
Even in the agricultural sector iron had little role to play. The economy thus remains in the chalcolithic milieu having little or virtually no impact of iron technology, whatsoever. The social priority was acquisition of power, winning over new fertile lands and bringing into their folds the people of divergent faiths and customs. This itself must have added to the emergence of powerful groups.

During the next stage (700-600 BC to 300 BC) however, the priorities do undergo some change. We come across some diversification in tool types employing it into other areas too. There are occasional cases of agricultural implements like ploughshares right from Proto-PGW period at Jekhara. Genwaria (BRW phase) also yields a ploughshare (700 BC level). Hoe and sickles have been unearthed from a few sites during the PGW-BRW cultures. There are cutting tools like axes and craft implements like chisels etc. The application of iron technology in other sectors could have been possible because of improvement in metallurgy itself. At the initial stage only wrought iron was being produced. It must have scored over simple copper objects as hunting and war tools but their efficiency as cutting and digging implements is suspect. Over the period the metallurgical skill improved. It is fully borne out by application of techniques like carburization, case hardening and quenching that added to the strength and sharpness of iron objects. Thus the technological development synchronises with its adoption in various sectors, viz., agriculture, crafts, building activity along with weaponry. As a result, the size of settlements expands. There is rise in demographic chart. With use of better tools and implements, items of craft show improvement; as a result, luxury goods show up in material remains of this period. NBP culture is a definite improvement over the previous BRW-PGW complex in their respective zones of the Gangetic Plains. Five kg. of rice grains were collected at Sonpur^[15] (Period IB) in Bihar. In upper Ganga plains wheat was the chief crop. Its cultivation requires frequent tilling/ploughing and irrigation. Literature mentions about practice of irrigation frequently. A breakthrough in wheat cultivation was possible only with better agricultural implements and tools for digging wells and canals. We come across agricultural implements at Atranjikhara during NBP phase. Jakhara, as stated above has yielded a ploughshare in late phase of PGW. The number increases by this stage.

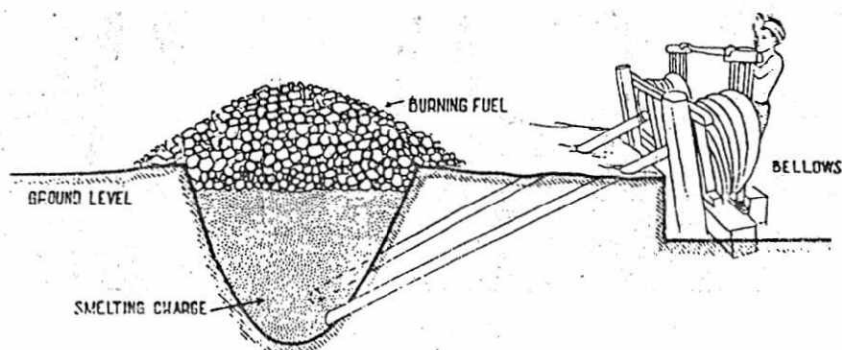
It may not be argued that the pace of socioeconomic life changes drastically during stage II. Nor the changes are exclusively attributable to iron technology. It is a complex phenomenon. The role of technology in this process, however cannot be minimised. Why the impact of a new innovation is not visible in early levels is because (a) the social adaptation of a new technology is very slow (b) the ores are to be located for better and greater use for proliferation of an upcoming technological innovation (c) the technology itself should improve and come of age to be effective. Once all these conditions are met with, it could exert an impact that becomes noticeable in the cultural milieu. However, the validity of this argument may get questioned under different circumstances like those of the megalithic culture of southern India. Despite a use of precious objects like gold

**A quern (PL.XII C) has been found from Senuwar, Chalcolithic level. The shallow and small pit could not have been used for corns. It must have served some purpose other than this. Similar stones must have been used by craftsmen for various purposes.*

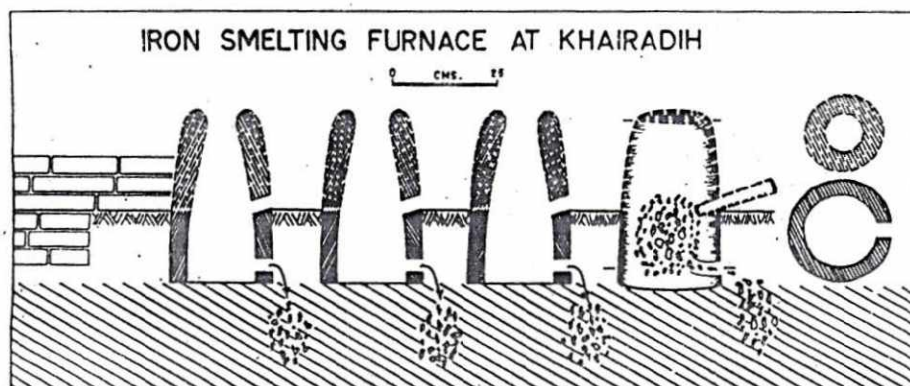
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A. Naikund furnace



B. Dhatwa furnace



C. Khairadih furnace

Fig. 2 : Showing three furnaces exposed during excavations at Khairadih in Dist. Ballia in Uttar Pradesh (Tripathi⁴⁸¹).

and inspite of well developed iron technology, they are far from a developed society. Iron was used in fairly large number in a rich variety but it has failed to bring about affluence in a broad way. Besides the metallurgical advancements, they also had a well stratified social structure and a political organization. Yet the culture remains at a low level of development. The socio-economic status is far from advanced. What are the reasons for such a state of affairs? One has to look for the causes elsewhere. While discussing the megalithic cultures above, we noticed a dominance of war and hunting objects. The agricultural implements that form a small percentage of total iron objects are hoe, sickle-blades or other digging tools. None of these could play a supportive role in agricultural activity on large scale. The ecological background into which these cultures flourish is equally inapt for this purpose. The mountainous terrain is far from conducive to cultivation at any considerable level. The economy had to be substantiated by hunting, scavanging (of forest products) and also marauding (Gurukkal, op.cit.). Ecology, therefore, seem to have been a strong deciding factor in this case in shaping the culture. This also explains why some centres grow while others remain stagnant at certain level of development for a long time.

We know that if techno-ecological factors are favourable, better tools and implements become a great assets in raising production. A sound economy is a fundamental requirement for socio-political changes. Conversely, one may argue that technology or for that matter economy does not grow without organisational structure. In answer, it may be postulated that to support any organisation certain amount of economic base is an essential pre-requisite. The archaeological data shows that right from the BRW and PGW cultural stage, we come across expansion of settlements. A relatively better cultural material, (as shown in the tables here) than the previous cultural horizons is unearthed. It is a continuing process –the smaller settlements expanding in size with the quality of life improving gradually. Literary evidence shows presence of Janapadas followed by Mahajanapadas. The prospering townships organised themselves for better trade and commerce through some kind of bodies that grew into powerful guilds. The guilds wielded much political influence during the subsequent times even when the political system was as powerful as during the Gupta rule. The trading community with its adventures frequently related in the Pali texts may be called the backbone of early Indian economic and social structure. Thus productivity and economy gave rise to strong and enterprising commerce groups that supported the society. The role of economy in politico-cultural upsurge may thus be established.

With rise of political organisation, kingship and the governance play a key role in deciding the social priorities. An organised society moves with faster pace. The sixteen Mahajanapadas are important example of consolidation of political power and an organised state machinery. It may be argued that iron technology contributes through intensifying the production of various craft commodities that is clearly borne out by the material milieu. This process of technological developments brings about economic and thus socio-cultural changes. However, the new ideas, innovations and the outcome of the technology are eventually to be utilized by the society. The social structure has to be in a state of readiness

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to adopt and adapt to the changes. "Its adoption must be perceived as advantageous to society; facilitating this is degree of knowledge about how to properly use the new idea"^[16]. Indeed it is the society that decides where and how it proposes to utilise its skills but at the same time the expertise has to be available to be harnessed and channellised. The Iron Age society could appreciate among other things the importance of technology. With its maturation, the utilitarian metal technology seem to have been channellised into all possible directions. It earns the label of Iron Age for its times. Iron Age becomes synonymous with innovations, growth and prosperity.

REFERENCES

1. Anantharaman, T.R., 1997. The Rustless Wonder – A Study of Iron Pillar at Delhi, New Delhi.
2. Erdosy, George., 1995. The Indo-Aryans of Ancient South Asia; Language, Material Culture and Ethnicity. Walter de Gruyter (ed.), Berlin, 1st Indian edition 1997, Munshiram and Manoharlal, Delhi.
3. Sharma, R.S., 1999. Advent of the Aryans in India, Manohar, New Delhi.
4. Witzel, Michael., 1995. Early Indian History: Linguistic and Textural Parametres, The Indo-Aryans of Ancient South Asia: Language, Material Culture & Ethnicity, G. Erdosy (ed.) 85-125, p. 110, op. cit.
5. Parpola, A., 1995. The Problem of Aryans and the Soma: Textural-linguistic and Archaeological Evidence, in G. Erdosy ed., op.cit. pp. 353-381.
6. Ghirshman, R., 1954. Iran, Penguin Book, p. 73.
7. Maddin, R., 1982. The Beginning of the Iron Age in the Eastern Mediterranean, Transactions of the Indian Institute of Metals, Vol. 35(1), pp. 14-34.
8. Young, T.C., 1976. The Iranian Migration into The Zagros, Iran, Vol. V, pp. 11-34.
9. Niyogi, P., 1914. Iron in Ancient India; Association of Cultivation of Science: Bulletin No. 12, Calcutta.
10. Banerjee, M.N., 1927. On Metals and Metallurgy in Ancient India-Metallurgy in Rgveda, Indian Historical Quarterly, Vol. III, 1-2, pp. 121-133.
11. Banerjee, M.N., 1929. Iron and Steel in Rgvedic Age, IHQ, Vol. V (Sept.), pp. 432-436.
12. Banerjee, M.N., 1934. A Note on Iron in Rgvedic Age, IHQ, Vol. III, pp. 364-366.
13. Waldbaum, J.C., 1980. The First Archaeological Appearance of Iron and the Transition to the Iron Age, The coming of the Age of Iron, T.A. Wertheim and J.D. Muhly (eds.), Yale University Press, pp. 69-98.
14. Tylecote, R.F., 1980. Furnaces, Crucibles and Slags, Coming of the Age of Iron', T.A., Wertheim and J.D. Muhly (eds.), New Haven, London, Yale University Press, pp. 83-228.
15. Roy, U.N., 1965. Prachin Bharat Mein Nagar Jivan Allahabad (Hindi), p. 325.
16. Chakrabarti, D.K., 1979. Early Iron in Indian Northwest, Essays in Indian Protohistory, B.R. Pub. Corp. Delhi, D.P. Agrawal and D.K. Chakrabarti (eds.) pp. 347-364.
17. Sharma, A.K., Personal Communication.
18. Ramchandran, K.S., 1974. Cairn Burials of Baluchistan Makran and Southwestern Iran: Their Character and Chronology, Puratattva, No. 7, pp. 82-87.
19. Stein, Sir A., 1929. Archaeological Tour of Waziristan and Northern Baluchistan;

V. Tripathi

- Memoirs of Archaeological, Survey of India No. 37, Delhi.
20. Stein, Sir A., 1937. Archaeological reconnaissances in North-western India and South-eastern Iran, Macmillan & Co., London.
 21. Mockler, Major., 1876. On Runis in Makran, Journal of Royal Asiatic Society IX, pp. 121-134.
 22. Gordon, D.H., 1950. The Early Use of Metals in India and Pakistan, Journal of Royal Anthropological Institute, No. 80, pp. 50-78.
 23. Lamberg-Karlovsky, C.C., and Humphries J., 1968. The Cairn Burials of South-eastern Iran East and West, New Series Vol. 18(3-4), (ed.) Tucci, Rome pp. 269-276.
 24. Tripathi, V., 1976. Painted Grey Ware: An Iron Age Culture of Northern India, Concept Publishing Co., New Delhi.
 - 24a. Sahi, M.D.N., 1994. Aspects of Indian Archaeology, Publication Scheme, Jaipur.
 - 24b. Tripathi, V., 1997. Stages of Painted Grey Ware Culture, Indian Prehistory: 1980, V.D. Misra and J.N. Pal (eds.) Dept. of AHC & Arch. Allahabad, pp. 318-322.
 25. Gaur, R.C., 1983. Excavations at Atranjikhhera, Munshiram Manoharlal, Delhi.
 26. Lal, B.B., 1954-55. Excavations at Hastinapur and other Explorations etc., Ancient India No. 10-11, Bull. Of ASI, No. 10-11.
 27. Dutta, A., 1992. Early Stages of Iron Technology and the Development of Regional Pattern in India, Man and His Culture: A Resurgence, Peter S. Bellwood (ed.), Delhi, pp. 293-308.
 28. De, Sudhin and Chattopadhyay, P.K., 1989. Iron Objects from Pandurajar Dhibi, Archaeometallurgical Studies, Steel India, No. 12, pp. 33-41.
 29. Tiwari, Rakesh, Personal communication and observation of the author.
 30. Tiwari, Rakesh., 1998. In Quest of Early Iron Age Sites in Karmansa Valley, Pragdhara Journal, of UP State Arch. Department No. 8, pp. 57-61.
 31. Deo, S.B., 1985. The Megaliths: Their Culture-Ecology, Economy and Technology, Recent Advances in Indian Archaeology (eds.) S.B. Deo, K. Paddayya, Deccan College, Pune.
 - 31a. Deo, S.B., 1998. Inaugural Address to National Seminar on Indian Archaeometallurgy in Archaeometallurgy
 32. Deo, S.B., and Jamkhedkar, A.P. 1982. Excavations Naikund, Bombay.
 33. Sundara, A., 1975. The Early Chamber tombs of South India - A study of the Iron Age Megalithic Monuments of North Karnataka, Delhi Univ. Publications.
 34. Moorti, U.S., 1994. Megalithic Culture of South India: Socioeconomic perspectives, Ganga-Kaveri Publishing House, Varanasi.
 35. Wertime, T.A., 1980. The Pyrotechnologic Background, The Coming of The Age of Iron, T. A. Wertime & J. D. Muhly (eds.) Yale University Press, pp. 1-24.
 36. Tylecote, R.F., 1980. Furnaces, Crucibles, and Slags, Coming of the Age of Iron, T.A. Wertime & J.D. Muhly (eds.) Yale University Press, New Haven London, pp. 83-228
 37. Chakrabarti, Dilip K., 1976. The beginning of iron in India', Antiquity L, pp. 114-124.
 38. Tripathi, Vibha and Prakash, Bhanu., 1986. Iron Technology in Ancient India, in Metal and Materials, Sept. 1986, Inst. of Metals. London, pp. 568-579.
 39. Tripathi, Vibha., 1982. Antiquity of Iron in Madhya Pradesh, in Indian Archaeology: New Perspectives R.K. Sharma (ed.), pp. 257-263.

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40. Tripathi, Vibha., 1990. Origin and Development of Iron in India and its Economic Implications, in History of Science and Technology, Vol. 6 (eds.) G. Kuppuran and K. Kumudamani, Sandeep Prakashshan, New Delhi.
41. Tripathi, K.K., 1995. Eran Excavations: Chalcolithic Culture and the Iron Age, in Studies in Indian Art and Archaeology Krishnamurti (K.D. Vajpai Comm. Vol.), (eds.) R.K. Sharma, R.C. Agrawal and O.P. Mishra, Aryan Books International, New Delhi, pp. 58-63.
42. Gaur, R.C., 1983. Excavations at Atranjikhhera, New Delhi.
43. Agrawala, R.C. and Vijaya Kumar (year 22), Mahabharat Myth or Reality, (note 12) S.P. Gupta and K.S. Ramachandran (eds.) New Delhi.
44. De, Sudhin and Chattopadhyay, P.K., 1990. Iron From Pandu Rajar Dhibi: Archaeometallurgical studies' Steel India 12(1), pp. 33-41.
45. Gaur, R.C., 1983. Excavations at Atranjikhhera, op cit., p. 128.
46. Lal, B.B., 1988. Oct. Seminar on New Archaeology and India, Comments, ICHR, New Delhi.
47. Gogte, V.G., 1982. Naikund Excavations (op.cit.) p. 11, Bombay, (see also appendix III, p. 56-59 and appendix II, pp. 52-55).
48. Tripathi, V., 1998. Iron Working in Ancient India - A Case Study, Archaeometallurgy in India V. Tripathi (ed.) Sharda Pub. House, Delhi, pp. 209-217.